UPPER TRISHULI-1 HEP (216MW)			
Client	Doosan Enerbility		
DHI's Subcontractor	Power Construction Corporation of China		
REPLY COMMENT			
Subcontractor	Power Construction Corporation of China		
Incoming Document			
Title of the Document	**Arrangement Drawing of Diversion Tunnel**		
Document/Drawing No.	UT1-C-010-CVL-DG-42001	Revision	0D
Review Document No.	**UT1-HEP-DHI-D-0207**	Reviewed Note No.	**RN-0113**
Received Date	**26.04.2022**	Review status	**RR**
Outgoing Document			
Previous Reply No.	RC-00xx	Previous Reply Date.	**06.04.2022**
Reply No.	RC-00xx	Reply date	**29.04.2022**

General Comments

The document under review is part of the Design Optimization Proposal process.

Comments to RC-0029

1. Tunnel lining:

"Reply: The shotcrete of the tunnel roof is designed as permanent lining which indicated in section

detail of UT1-C-010-CVL-DG-42001."

OE´s comment:

A proof of the durability of the shotcrete as a permanent tunnel lining of the Diversion Tunnel with

pressurized and high flow velocities has not been provided yet especially in regards of roughness

and irregularity of shotcrete lining.

Reply: According to the experience of Upper Trishuli 3A Hydropower Station, the diversion tunnel might be exposed to the risk of the lining concrete wear caused by the bed load during the flood period. In case of a dry-season 20 year return period flood or a flood-season 5 year return period flood, the maximum flow velocity of the diversion tunnel is 13.1 m/s and 12.2 m/s respectively, which are both within the velocity range of the scour-resistance ability of the lining concrete. After the hydraulic calculation of diversion tunnel, the capacity of over-discharge can meet diversion requirement. The

detail of diversion concept please refer to the 'design optimization proposal for diversion tunnel works (Rev.D) issued at 29th Nov.2021.

2. Concrete Plug:

Reply: Concrete plug is added and shown in revised drawing as per comment.

OE´s comments:

The concrete plug is indicated tentatively. The detailed design shall be considered as per drawings

UT1_C_CFDR_039 to _047 (DKJV 2018).

Reply:

According to the structural calculation for inlet structure of diversion tunnel Rev.0B (UT1-C-010-CVL-DC-42004), (1)condition 1:in the plugging case, the elevation of riverbed is 1250.17m and the head of plugging is about 19.04m. For convenience of calculation, the head takes as 20m.

(2) condition 2:upstream water lever (20-year return period flood), the head of plugging is about 29.11m, For convenience of calculation, the head takes as 30m.

According to Engineering Geological Report, the surrounding rock of the concrete plug of diversion tunnel is quartz schist/mica schist, supposed as rock class III , The shearing strengths of between rock mass and concrete: f=0.65, c=0.45MPa for safety.

Table 3.1 Mechanical parameter of surrounding rock

Class of surrounding rock	Unit weight	Uniaxial compressive strength (UCS) of intact rock	Elastic modulus Of rock mass	Poisson's ratio of rock mass	Rock mass/rock mass shear (shearing) strength				Uniaxial compressive strength of rock mass, (UCS)	Tensile Strength of rock mass
					Peak		Residual			
	γ (kN/m³)	σ_c (MPa)	E_m (GPa)	μ	Φ_{peak} (°)	C_{peak} (MPa)	Φ_{res} (°)	C_{res} (MPa)	σ_{crm} (MPa)	σ_{trm} (MPa)
Ⅰ	27.0	60	30.0	0.20	50	5.0	40	3.33	27.5	2.75
Ⅱ	27.0	60	20.5	0.25	48	2.5	38	1.67	13.0	1.3
Ⅲa	26.5	60	10.0	0.25	45	1	36	0.66	4.8	0.48
Ⅲb	26.5	60	5.0	0.28	42	0.8	33	0.53	3.6	0.36
Ⅳ	26.0	60	2.3	0.30	35	0.5	28	0.33	1.9	0.19

The critical slip surface appears between concrete and surrounding rock. The stability of the concrete plug is calculated by the following formula:

$$FS = \left(\sum W \tan\phi + cA\right) / \sum P$$

Where:

∑W——sum of total normal forces acting on the bottom sliding plane;

∑P——sum of total tangential forces acting on bottom sliding plane;

A——counted area (Assumption: The top arch area is not considered; Straight sidewall area is considered with a reduction factor of 0.8.);

C——shearing cohesive force;

φ——internal friction angle, friction coefficient $f = \tan\phi$.

Table 1 Operational conditions and load combination

Load combination	Main situations taken into consideration	Force category			FS of Sliding stability
		Dead load	Water pressure	Uplift pressure	
Usual combination	Working condition 1	√	√	√	2
Unusual combination	Working condition 2	√	√	√	1.7

the result is as follows:
if the length of plugging is 5m.

Force (kN)	Usual combination	Unusual combination
Dead load	2740.8↓	2740.8↓
Water pressure	3969.5→	6210.1→
Uplift pressure	1120.3↑	1120.3↑
Normal forceΣW	1620.5↓	1620.5↓
Tangential forceΣP	3969.5→	6210.1→

if the length of plugging is 20m.

Force (kN)	Usual combination	Unusual combination
Dead load	10963.2↓	10963.2↓
Water pressure	3969.5→	6210.1→
Uplift pressure	4481.2↑	4481.2↑
Normal forceΣW	6482.0↓	6482.0↓
Tangential forceΣP	3969.5→	6210.1→

Conclusion

Load combination	Rock class	Cohesive force C (kPa)	f=Tanφ	Plug Length (m)	Calculated FS	Standard FS
Usual condition	III	450	0.65	5	6.27	2
				20	25.09	2
Unusual condition	III	450	0.65	5	4.01	1.7
				20	16.04	1.7

According to preliminary calculation results, the reserved length of the plug and the form of excavation section can meet the structural requirements completely. the length of plug concrete has finally been decided as 20m to secure the safety of inlet tunnel that locates near plug concrete and to insure space for grouting. Further calculation will be carried out by studying rock mass condition after excavation.

3. Diversion tunnel outlet:

Reply: The Contractor added titles and numbers of reference drawings as per comment.

OE´s comments:

For the Diversion Tunnel outlet, concrete outline drawings shall be provided..
Reply: Outline and reinforced drawing of outlet structure of diversion tunnel will be provided subsequently. DWG. No.UT1-C-010-CVL-DG-42009.